

Effect of chloramine concentration on biofilm maintenance on pipe surfaces exposed to nutrient-limited drinking water

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Abstract

This study addresses the effect of specific monochloramine concentration on biofilm density and bacterial functional potential in nutrient-limited water. The efficacy of monochloramine residual maintenance on biofilm density was studied at a range of 0.5 to 2.0 mg/l, using a 3:1 (w/w) dosing ratio of chlorine to ammonia, with the provision of low-nutrient water (0.18 mg/l as total organic carbon, 0.055 mg/l as biodegradable dissolved organic carbon, and 10.5 µg/l as assimilable organic carbon) using a granular activated carbon (GAC) filter. Biofilm density was monitored using biofilm bacteria counts and analysis of the physiological substrate utilisation profiles in Biolog gram-negative (GN) micro-plates.

The monochloramine residuals were maintained stable in the low-nutrient water pipes, which contributed to the inhibition of biofilm density. Increasing the monochloramine residual from 0.5 to 2.0 mg/l suppressed the total cells and heterotrophic plate count (HPC) bacteria in the biofilms by about 1 and 2 log units, respectively. The biofilm HPC densities were more sensitive to monochloramine residual, and the reduction in biofilm HPC densities expressed as log CFU/cm² showed an exponential relationship with the increase in monochloramine residual. The Biolog micro-plate-based community-level assay showed that the biofilm communities occurring at 3 levels of chloramination were distinguished by the differences in their substrate utilisation potentials. The functional/metabolic potential of the biofilm community's ability to utilise specific substrates was much lower at higher monochloramine concentration. Results suggest that the maintenance of a consistently high-level monochloramine residual in the low-nutrient water system led not only to a reduction in biofilm density on pipe surfaces but also depressed potential functional/metabolic ability of the biofilm community.

Keywords: biofilm, monochloramine residual, low-nutrient water, HPC, physiological substrate utilisation profile, GAC